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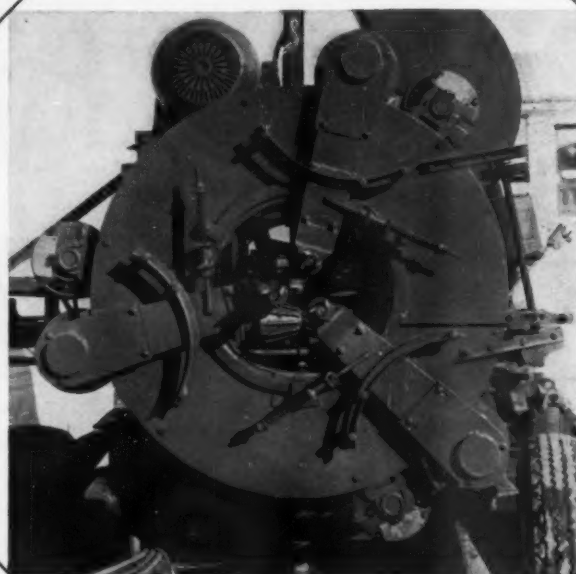
EXPERIMENTAL....



TREE DELIMBING MACHINE

E. W. FOSS AND H. J. HURME

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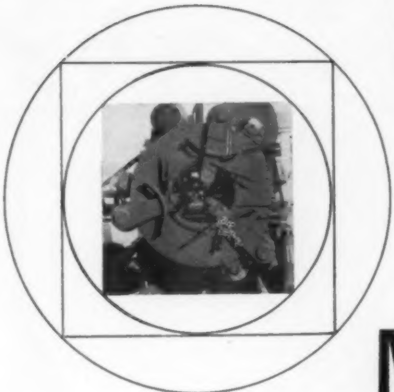
Adapted from a thesis by Herbert J. Hurme, "The Design and Development of a Tree Delimbing Machine". Submitted to the Graduate School June 1957 in partial fulfillment of the requirements of the Ph.D. degree.

EXPERIMENTAL TREE DELIMBING MACHINE



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In the last twenty years, the harvesting of forest products in the Northeastern States has become increasingly mechanized. The two most important changes have been the shift from horses to tractors, and from the two-man crosscut saw to the gasoline powered chain saw. These two changes have both speeded up and decreased the labor of felling trees, bucking trees into saw logs or pulpwood, and skidding the logs and pulp to a roadside deck or landing. The job of delimbing trees—one of the most time consuming and dangerous of the whole harvesting job—must still be done by hand with the common axe. While a chain saw or portable circular saw can be used with limited success in delimbing trees, no machine has come into use to change this job to a mechanical task. This bulletin is a report of the experimental development of a type of machine to perform this operation.

Need For Tree Delimbing Machine In Forest Plantations

Many of the over one-half million acres of softwood forest plantations in New York State are becoming stagnant and will not produce timber of maximum commercial value unless thinning operations are carried out in the near future. At the time of planting, the tree seedlings are placed close together to secure rapid ground cover and maximum growth. When the trees grow larger, thinning operations must be made, as with agricultural crops, to maintain the best growth conditions. Diameter growth, the important factor in obtaining maximum volume of usable wood fiber, is seriously restricted by crowding. Stagnation of growth results from overcrowding and the plantations become more susceptible to insect, disease, and mechanical injury and do not produce material of the most value.

High labor costs and the low return received from the sale of the products (fence posts, pulpwood, etc.) obtained from the small trees felled in the early thinning operations have placed these operations into the expense category. Plantation owners have hesitated to invest money or labor in the plantations

when the financial benefits are a long time in coming.

A large proportion of the labor required in harvesting the material from the trees felled in the thinning operations is in the removal of the limbs. Mechanization of this phase of the operation could help to reduce the thinning costs, or possibly even bring immediate financial returns to the plantation owners.

The pulpwood industry also very definitely feels a need for mechanized limb removal to lower the pulpwood harvesting costs. Many pulp and paper companies, particularly those which own large tracts of land from which they harvest their pulpwood, consider a machine that would satisfactorily delimb trees and cut the bole into desired lengths in continuous operation as a most urgently needed piece of equipment.

Description of Machine and Its Operation

Figure 1. Experimental tree delimbing machine

Work was undertaken to design and develop a machine for the purpose of delimbing trees felled in plantation thinning operations. First, a pilot model was designed and constructed to test a principle of operation proposed for the limb removal. Three rapidly rotating 3-winged cutters revolved around the bole of the tree as it was drawn through the machine by powered feed rolls. These cutters, $2\frac{1}{8}$ inches in diameter and two inches long, were guided along the surface of the bole by adjacent shoes held against the bole by spring pressure. The results of the test operations with the pilot model were encouraging.

A working model which is suitable for use in actual plantation thinning operations was then designed and constructed. Figure 1 illustrates this working model. This experimental machine was mounted on a truck chassis with the idea that it would be used in row thinning operations, such as when every third row of trees would be removed.

Basically, the machine consists of a rotating steel cylinder 30 inches in diameter and 30 inches long which is supported by an internal framework. As illustrated in figure 2, the rotating cylinder has 3 one horsepower electric motors mounted on the outer circumference which provide power through belt drives to the three 3-winged cutters ($2\frac{1}{8}$ inches by 2 inches) that do the actual work of the limb removal. Each motor furnishes power to only one cutter. Each motor transmits power to a countershaft by means of a V-belt. A "timing" belt is then used to transmit the power from the countershaft to the cutter. The timing belt is enclosed in the member (cutter arm) extending from the outer circumference of the cylinder toward the center of the machine. (See figure 2). Each of the cutter arms pivots about the end of the countershaft. A linkage connects the cutter arm to a rotating ring which positions the cutters equidistantly for any desired diameter opening. The rotating ring has an extension which is actuated by a nut traveling on a threaded shaft. A reversible electric motor turns the threaded shaft by means of a V-belt drive. Limit switches at each end of the threaded shaft prevent overriding of the nut. By operating the 1/3 horsepower electric control motor (mounted on the rotating cylinder), movement of the cutters can be obtained for opening or closing

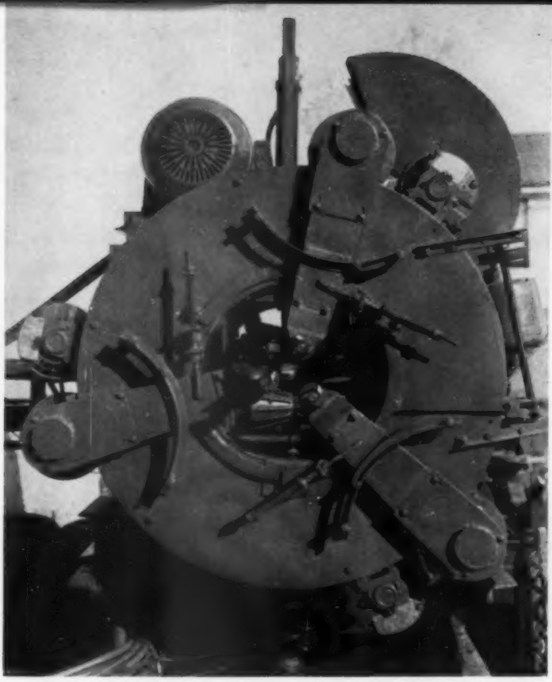

Figure 2. In-feed end of delimbing machine with protective shield removed

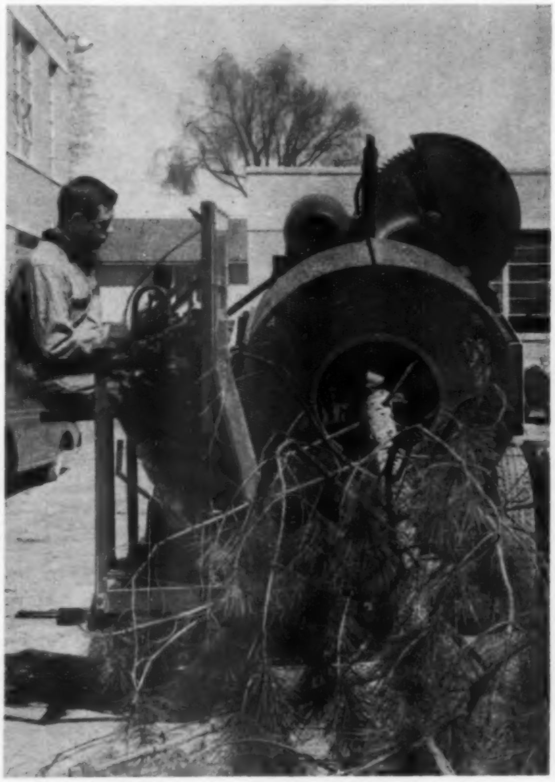

Figure 3. Red pine at start of delimbing operation

the cutting circle for different tree diameters. Each cutter arm has a shoe that is in line with the side cutting edge of the cutter and is located just behind the cutter. This shoe rides against the bole of the tree and under uniform conditions prevents the cutter from cutting into the side of the bole. The shoe is held against the bole surface by a spring in the control linkage.

Behind the cutters are located two hourglass shaped feed rolls which center the tree and provide the power for moving the tree through the machine. Hydraulic controls are used to open and close the feed rolls, as well as to regulate the pressure of the rolls against the bole. A hydraulic motor drives the lower feed roll and a control valve is used to vary the motor speed in order to provide a variable rate of feed for the the tree. For improved performance and a greater rate of output, it is desirable to have a relatively slow feed rate while the cutters are working through branches and a more rapid rate of feed in bringing the next group, or whorl, of branches up to the cutters.

To begin the delimbing operation, as illustrated in figure 3, the three arms containing the cutters are swung outward and the butt of the tree is inserted between the feed rolls (with the top of the tree remaining on the ground). The feed rolls are then

Figure 4. Machine removing limbs from red pine

closed on the bole, the cutter arms brought into contact with the bole, and the machine pivoted to align the cutters with the sides of the bole. As the tree is drawn through the machine by the feed rolls, the three rapidly rotating cutters (10,000 RPM) revolve around the tree (at 40 RPM) and cut off the branches. The branches fall in front of the machine (see figure 4) and the bole moves through the machine to be cut into desired lengths by a circular cut-off saw. Figure 5 shows a delimbed Norway spruce bole being discharged from the machine. The cut-off sections then roll back on to the ground. To further mechanize this woods operation, these bolts could be gathered at this point in bundles of ½ to 1 cord and held by straps or chain, to be brought out of the woods by modern bulk handling methods. An endboard on the deck serves as a guide for cutting either four or six-foot lengths. Some Norway spruce delimbed and cut into six-foot lengths are illustrated in figure 6. Notice how the limbs are cut off even with the surface of the bole. Some bark removal and fiber loss can be noted on crooked sections. The amount of bark removal and fiber loss that occurs depends largely on the crookedness of the tree and the experience of the machine operator.

After the butt of the tree is placed between the feed rolls, the remainder of the operation is controlled from the control station located at the left side of the machine (see figure 3). On this experimental machine, the butt of the tree must be lifted off the ground manually; however a hydraulically controlled boom could be used on a production machine to lift the tree off the ground. The driving of the truck, or ground travel, is also performed from the same control station by means of remote controls. In third-row plantation thinning, all of the

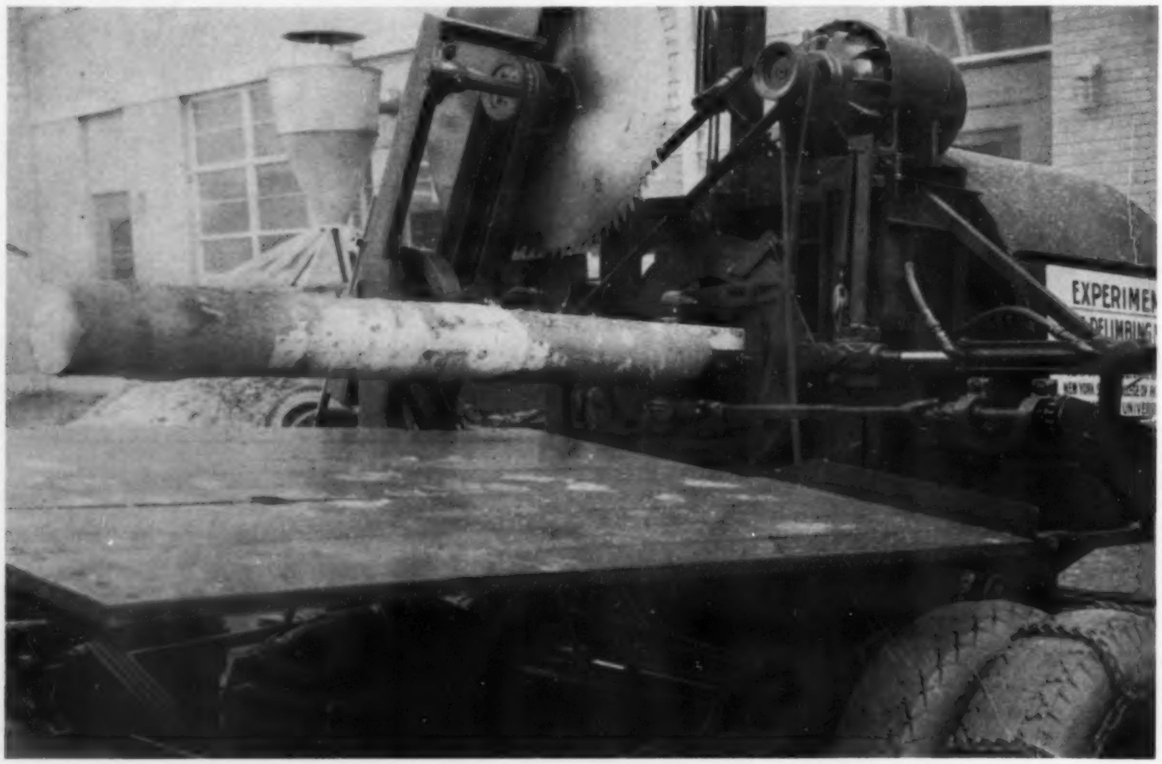

Figure 5. Bole of delimbed Norway spruce being discharged from out-feed end of machine

trees could be first cut down in every third row and and then the machine moved up the row of felled trees for the delimbing and bucking operation. In plantations where the trees were planted at six foot by six foot spacings, the machine would be moved approximately six feet at a time up the row.

To help in aligning the cutters with the surface of the bole at the beginning of the delimbing operation and to avoid cutting away wood unnecessarily at crooks in the tree, the machine can be pivoted in the horizontal and vertical planes. When the tree has moved through the machine to the point where the top of the tree no longer touches the ground, a tree alignment control is brought into use to move the tree in relation to the cutters. This tree alignment control is used to keep the cutting edges of the cutters parallel to the surface of the bole as crooks occur in the tree and to hold the bole during the cutting by the cut-off saw. Figure 5 shows the bole coming out through the tree alignment control.

A 30 horsepower air-cooled gasoline engine is used to power the delimbing machine. This engine drives an International Harvester Electrall Generator Unit to furnish the electricity for the five electric motors. The Electrall is rated at a capacity of 10 KVA, 3 phase, 60 cycles, and 120/208 volts and is built for use with the International Harvester Farmall 400 and International W-400 Series tractors. In addition, the gasoline engine drives a 20 GPM variable volume hydraulic pump to provide hydraulic power for the six hydraulic control cylinders and one hydaulic motor used on the machine. A five horsepower electric motor is used to turn the rotating cylinder and also to drive the cut-off saw.

Although the truck engine is used only to move the machine on this experimental model, it would

Figure 6. Norway spruce delimbed and cut into six-foot lengths by the machine

be possible to use one engine for both propelling the machine and for driving the electric generator and hydraulic pump.

This experimental machine can handle trees ranging in diameter from 2½ to 9 inches. A machine could be constructed without great difficulty to handle larger diameter trees. With modification to permit the use of stronger "timing" belts in the cutter drives, the capacity of this experimental model could be about two cord equivalents per hour. At the present time the small timing belts used are inadequate to withstand sudden shock loads that are placed upon them when the cutters are subjected to severe shocks. Wider or heavy duty timing belts could correct this difficulty. With other small modifications and under good working conditions, it would seem reasonable for this type of machine to be able to delimb and buck into lengths four cords per hour.

The estimated total cost of construction of a machine similar to the experimental model would be between $7,000 to $8,000.

To justify ownership of the machine, the annual use must be rather substantial. It would not be practicle for small plantation owners to purchase a machine of this type. The services of a machine could be made available to small plantation owners either through joint ownership, or by custom operation. Custom operators, and pulp and paper companies having considerable yearly usage, could more easily justify the purchase of such a machine. Based on current wages and costs of materials, calculations indicate that the machine could be effective in reducing harvesting costs in plantations and other woods operations if the annual volume handled by the machine were 250 cords or more. Of course, simplification of the machine, and the resulting lower cost, could make it available to more people.

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